



US Army Corps
of Engineers
North Central Division

GREAT LAKES LEVELS

Update Letter No. 97

August 2, 1993

Measurement of Record High Flows in the St. Lawrence River

Background/Objectives

Measurements of high flow conditions in the St. Lawrence River were carried out by the Corps of Engineers, Environment Canada and other cooperating agencies during May-June 1993. They were done under the auspices of the International St. Lawrence River Board of Control which is responsible for recommending outflows from Lake Ontario, on a weekly basis. Because of high water supplies to Lake Ontario, exceeding those of

the past, the Board recommended and the International Joint Commission (IJC) approved on February 18, 1993 operations under Criterion (k). Criterion (k) allows for outflows to give all possible relief to riparian interests upstream and downstream. Then, during the early spring months, the levels on Lake Ontario rose sharply due to heavy precipitation, and all-time record supplies in April necessitating releases beyond those specified in the regulation plan. Figure 1 shows the levels of Lake Ontario

over the last eight months. The maximum outflow specified under the regulation plan is 310,000 cubic feet per second (cfs). However, with the Board authorized by IJC to operate under Criterion (k), the level of Lake Ontario continued to rise and exceeded Criterion (h) level (75.37 meters). Criterion (h) level is the maximum level which the Board attempts to keep the Lake from exceeding. The Lake reached a seasonal high of 75.65 meters on May 5-8. Outflows were initially increased to 350,000 cfs, a 13%

LAKE ONTARIO LEVELS 1992-1993

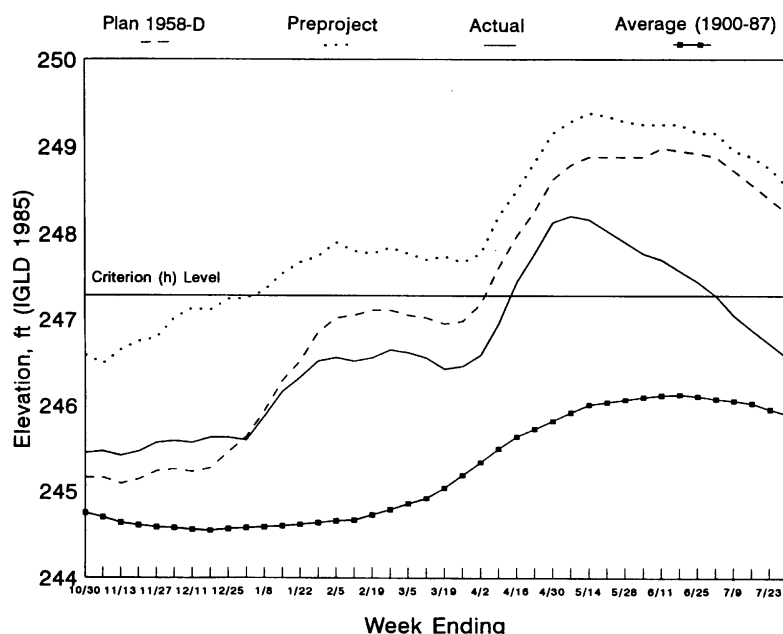


Figure 1. Benefits of Lake Ontario Regulation.

increase above the maximum plan outflow. The Board approved 24-hour increases twice weekly for a period of three weeks up to 385,000 cfs to closely monitor and determine any adverse effects it might have on the shoreline and environmental interests. This is because such high flows had never been released before (prior to or after the project).

A monitoring program of visual observation was established and carried out during these high flow tests. Of particular concern were the effects of high flow velocity on commercial navigation in critical reaches of the river. The high flows have the potential to create dangerous cross currents as well as high velocities. It became

necessary to conduct velocity measurements in critical reaches of the St. Lawrence River. This was an excellent opportunity to obtain hydraulic data of the river. The measurements were conducted by the Detroit District (NCE) in cooperation with the St. Lawrence Seaway Development Corporation (SLSDC), St. Lawrence Seaway Authority (SLSA), Environment Canada (EC), New York Power Authority (NYPA), U.S. Army Engineer District, Buffalo (NCB), and the U.S. Army Corps of Engineers, Waterways Experiment Station (WES).

The Board initially decided to conduct a 24-hour test to determine the effect of increasing Lake Ontario's outflow from

350,000 to 385,000 cfs. This test was conducted between the hours of 4:00 a.m., May 20, 1993 to 4:00 a.m., May 21, 1993. Following the initial test, a series of flow increases to 385,000 cfs for 24 hours, twice a week, on Tuesday and Fridays were initiated, from May 24, 1993 to June 11, 1993. During the days of flow increases, which were based on the preference of shipping interests, river navigation was restricted from Ogdensburg, New York to St. Zotique, Quebec, a total of approximately 60 miles. Commercial navigation did not take place during the test periods when the flow was at 385,000 cfs because of safety. This restricted reach of the river required ship anchorage at specified areas. It

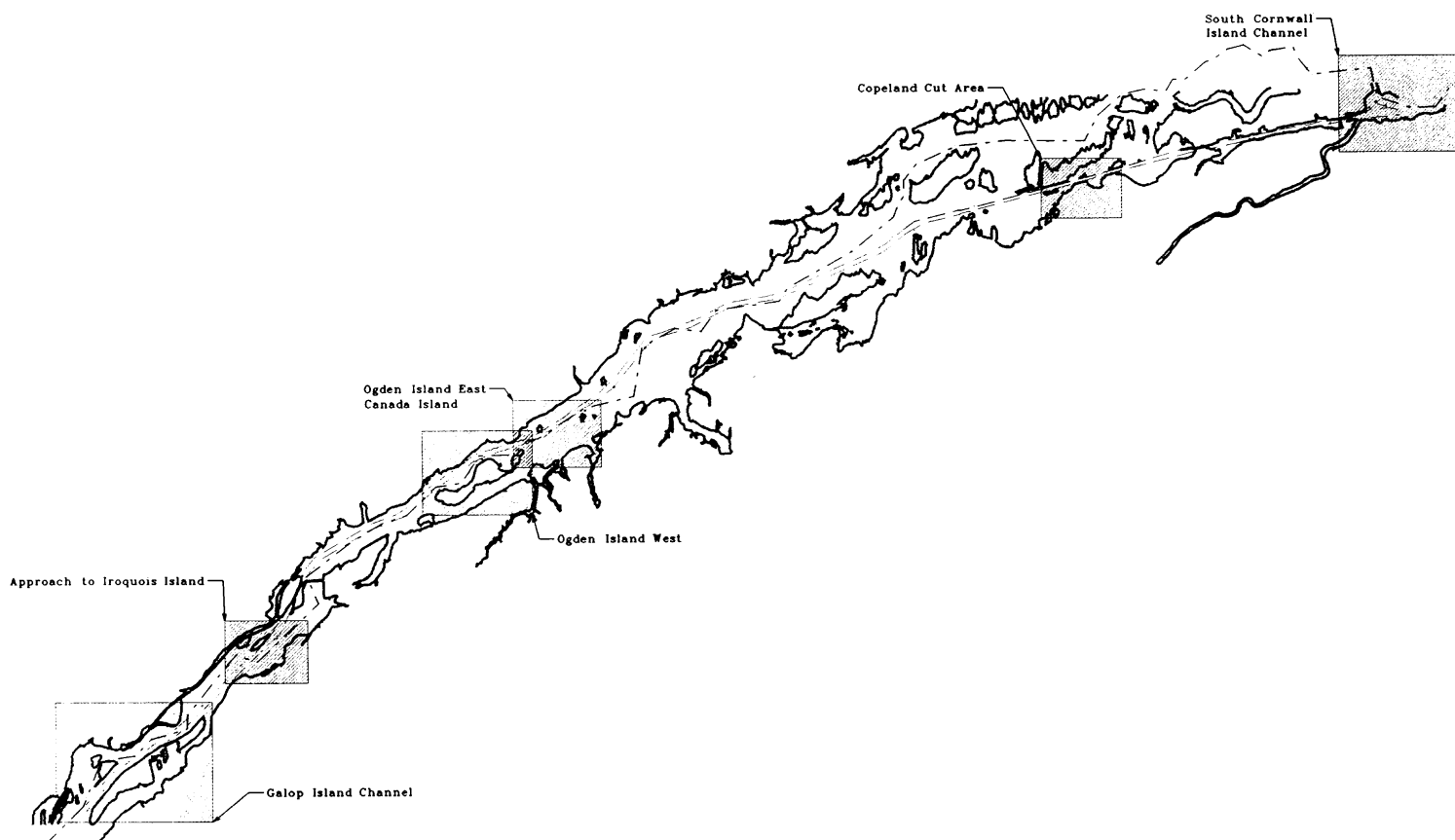


Figure 2. Critical Areas of the St. Lawrence River.



Figure 3. U.S. Army Corps of Engineers Survey Boat.

was anticipated that there would be residual flow effects in the river for a period of about 12 hours after the flow changes ended. Figure 2 is a map showing the areas of concern.

The objectives of the increased flow test period were to: (a) determine the reaction times in the system by plotting water levels at all gages in the system; (b) look at erosion, particularly at the upstream end of Long Sault Island which had been experiencing some erosion; (c) assess impacts on the training dike in the South Cornwall Channel; (d) obtain velocities in the critical areas of the river; and, (e) determine the necessity for limiting operation of the Iroquois Lock to restrict pleasure craft during the high flow

periods.

Standard Velocity Measurements

The first series of measurements were conducted during the period of May 20-28, 1993, to correspond with the high flow test period and two of the subsequent high flow days. The measurement series concentrated on the collection of point velocities at the following critical areas in the St. Lawrence River; (a) South Cornwall Channel from Snell Lock downstream to the International Bridge; (b) Copeland Cut; (c) North Channel, Ogden Island; (d) approach to Iroquois Lock above Presqu'île and Toussaint Islands; and, (e) Galop Island.

The point velocities were taken with standard current meters, at an 11-foot depth, for between three and six locations at each of the above critical areas. The 11-foot depth has been determined previously as a critical depth for ships navigating through the St. Lawrence River. A standard current meter assembly includes a meter with cups that resemble an anemometer (used for measuring wind speed), fins to orient the meter into the flow, and a lead weight to hold it at specific vertical depths below the water surface (see Update Letters 84 and 85 for more detailed information on Great Lakes flow measurements). The locations of the measurements were controlled through the use of a

satellite global positioning system (GPS) receiver on board the USACE survey launch, provided by the SLSDC. Velocity measurements were taken during the 385,000 cfs flow periods, as well as the 350,000 cfs flow periods to determine the changes in velocities for these two flow rates at these locations. The measurements were also compared with prior drogoue measurements of 1976 and 1986 for these areas at differing flow rates.

Preliminary analysis of the limited data collected tend to indicate there are no large increases in velocity for the test points measured at 385,000 cfs in comparison with the points measured at 350,000 cfs. There was a moderate increase in velocities at the high flow rate in the Copeland Cut area and the approach to Iroquois Lock above Presqu'île and Toussaint Islands; and a small increase in the Galop and Ogden Island areas, and South Cornwall Channel. In many of these areas, the velocity exceeded 4 feet per second (fps), which is considered a threshold limit for safe navigation.

Acoustic Doppler Current Profiler Measurements

A second set of intensive measurements of velocity magnitude and direction data for the full vertical depth, across multiple cross sections in six critical areas, were conducted during the period of June 2-11, 1993 using an acoustic doppler current profiler (ADCP). These six areas included the five locations previously measured along with the addition of the American Narrows area.

The ADCP was provided by WES along with a hydraulic engineer and technician to assist with the operation of the meter and collection of data.

Data were collected at flows of 350,000 and 385,000 cfs for the following areas: at 8 cross-sections in the South Cornwall Channel and Pollys Gut area; at 17 cross-sections in the Copeland Cut and 12 cross-sections above Iroquois Lock; at 18 cross-sections in the Galop Island area; and, 13 cross-sections in the Ogden Island area. In addition, measurements were made at 14 cross-sections in the American Narrows area at a flow of 350,000 cfs, and 4 cross-sections in the North Cornwall Channel at 385,000 cfs.

The ADCP transmits acoustic pulses from an assembly of four transducers mounted on the survey boat. (Figure 3). The ADCP then listens to and processes the echos from scatterers in the water column to determine a change in the frequency. Sound is scattered primarily by zooplankton and/or small particles of suspended sediment. The difference in frequency between the transmitted and reflected sound is proportional to the relative velocity between the ADCP and the scatterers. Velocity magnitude and direction information were collected for each half-meter of depth, for several water columns across the cross-section. Figure 4 shows the magnitudes of the east-west velocity components, along a south-to-north cross-section paralleling the International Bridge over the South Cornwall Channel, with outflows at 350,000 cfs. Figure 5 shows the velocities

at the same cross-section with flows of 385,000 cfs.

Currently, reduction and analysis of the 208 doppler measurements are ongoing. As can be seen from Figures 3 and 4, the data provided by the ADCP are far more detailed than point measurement data previously obtained. Many useful facts about the river velocity can be obtained through analysis of these data, such as: the magnitude of the velocity for each half-meter depth as well as its directional orientation; the distribution of the velocities throughout the cross-section; the frequency of occurrence of the various velocities; and, the total flow passing through the cross-section. Figures 4 and 5 for example, show that, although the maximum velocity has not been increased, the frequency of occurrence of the highest velocities has increased with the 385,000 cfs flow as compared to the 350,000 cfs flow, and the highest velocities have shifted to the right side of the cross-section. This increase in frequency and shift could create a hazard to navigation. These analyses will continue for all 208 measurements to fully address the impacts and effects of the increase in flow from 350,000 to 385,000 cfs.

Additional Field Efforts

Additional measurements are planned to be conducted in the fall at the same locations in the river, at lower flows. These additional measurements will increase the knowledge of the dynamics of the flows in the river, and will provide a broader range of flow conditions for additional

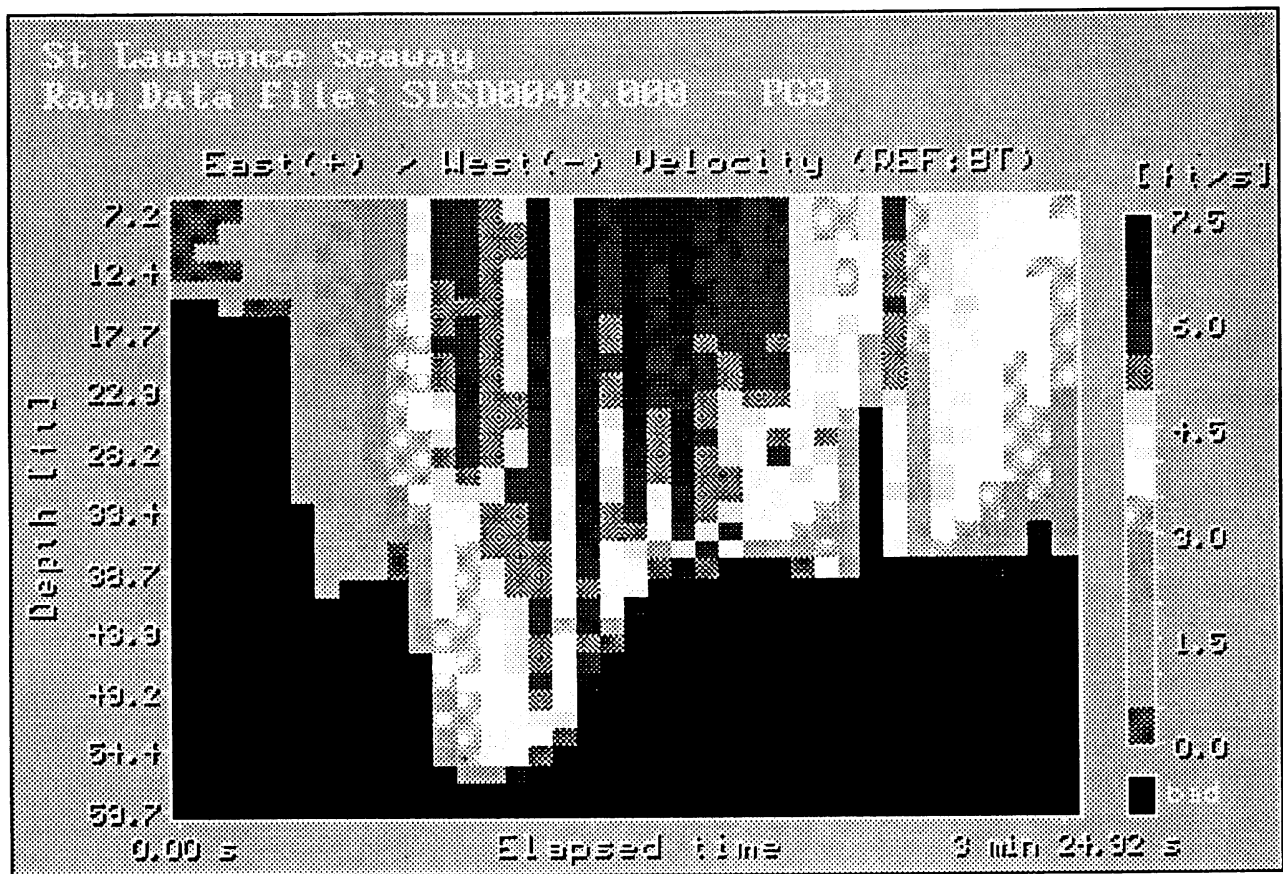


Figure 4. Velocities under South International Bridge at 350,000 cfs.

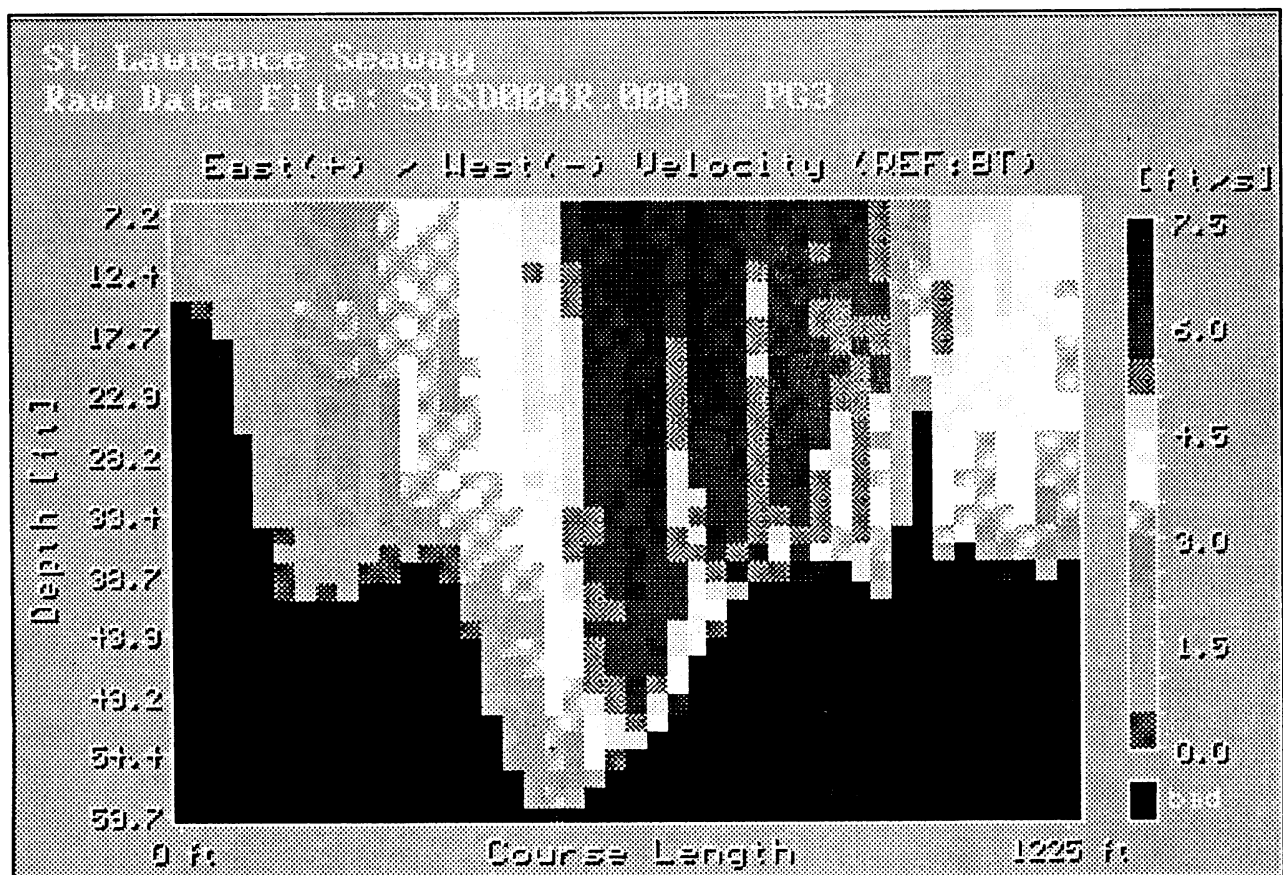


Figure 5. Velocities under South International Bridge at 385,000 cfs.

comparison with the higher flows of 350,000 and 385,000 cfs. This knowledge, in turn, could be used to calibrate computer models for determining maximum practical safe navigation limits and design of channels and potential structures to minimize adverse effects of high flows on navigation and riverine interests.

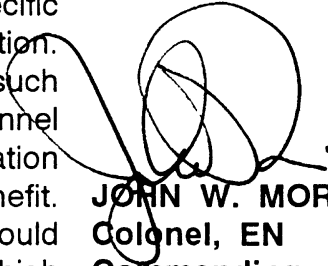
Hydraulic Model Development and Channel Design Studies

New modeling techniques and the availability of the additional data collected will assist in developing new mathematical

models for three critical reaches: Galop Island to Iroquois Lock; the Ogden, Canada, and Murphy Islands area; and the Copeland Cut. Such models could be used to predict the velocity magnitude and direction under various scenarios of Lake Ontario levels and outflows. Such analyses would also be valuable in determining the effects a specific flow rate may have on navigation. With future development of such models, and improved channel designs, commercial navigation and other interests could benefit. For example, navigation could decide to operate when such high

flows are necessary for regulation in the future.

Additionally, these models will help in studies related to new channel designs that may be needed to accommodate the higher water supplies being received than the original project was designed to handle.



JOHN W. MORRIS
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Commanding

Great Lakes Basin Hydrology

In July, precipitation and water supplies to Lakes Superior and Michigan-Huron were above average, while on the lower lakes, Erie and Ontario, these two hydrologic factors were less than average. To date in 1993, precipitation has been 10% above average on the entire Great Lakes basin. In comparison to their long-term averages (1900-1992), the July monthly mean water levels of Lakes Superior, Michigan-Huron, St. Clair, Erie and Ontario were 2, 11, 15, 15 and 10 inches respectively above average. Based upon the above information, shoreline residents on Lakes Michigan-Huron, St. Clair, Erie and Ontario are cautioned to continue to be alert to adverse weather conditions, as these could compound an already high lake level regime. Further information and advice will be provided by the Corps of Engineers should conditions worsen.

The precipitation, water supplies, and outflows for the lakes are provided in Table 1. Precipitation data include the provisional values for the past month and the year-to-date and long-term averages. The provisional and long-term average water supplies and outflows are also shown.

Table 1
Great Lakes Hydrology¹

PRECIPITATION (INCHES)								
BASIN	JULY				YEAR-TO-DATE			
	1993 ⁶	AVG. ⁷	DIFF.	% OF AVG.	1993 ⁶	AVG. ⁷	DIFF.	% OF AVG.
Superior	4.8	3.2	1.6	150	18.6	16.3	2.3	114
Michigan-Huron	3.1	3.0	0.1	103	19.6	17.6	2.0	111
Erie	3.0	3.3	-0.3	91	21.4	20.4	1.0	105
Ontario	2.5	3.1	-0.6	81	20.9	19.8	1.1	106
Great Lakes	3.5	3.1	0.4	113	19.7	17.9	1.8	110

LAKE	JULY WATER SUPPLIES ⁸		JULY OUTFLOW ³	
	1993 ²	AVG. ⁴	1993 ²	AVG. ⁴
Superior	170,000	130,000	77,000	81,000
Michigan-Huron	160,000	127,000	205,000 ⁵	195,000
Erie	-11,000 ⁸	4,000	232,000 ⁵	211,000
Ontario	20,000	24,000	317,000	259,000

¹Values (excluding averages) are based on preliminary computations.

²Cubic Feet Per Second (cfs)

³Does not include diversions

⁴1900-89 Average (cfs)

⁵Reflects effects of ice/weed retardation in the connecting channels.

⁶Estimated

⁷1900-91 Average

⁸Negative water supply denotes evaporation from lake exceeded runoff from local basin.

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